Lung Pressures and Lung Compliance

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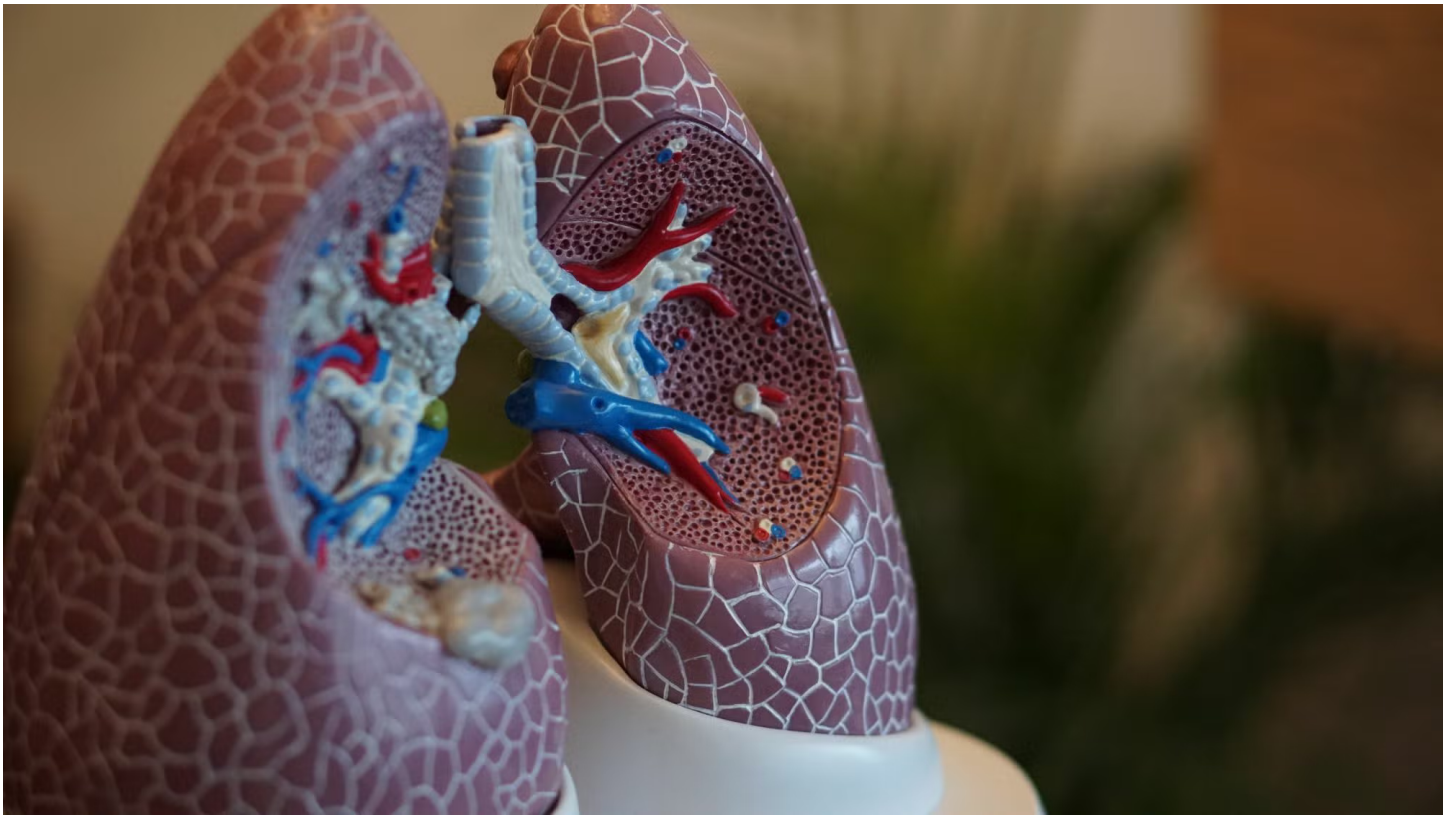
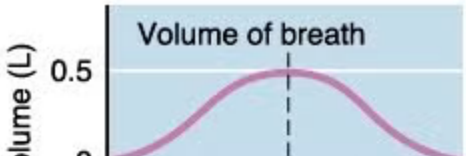


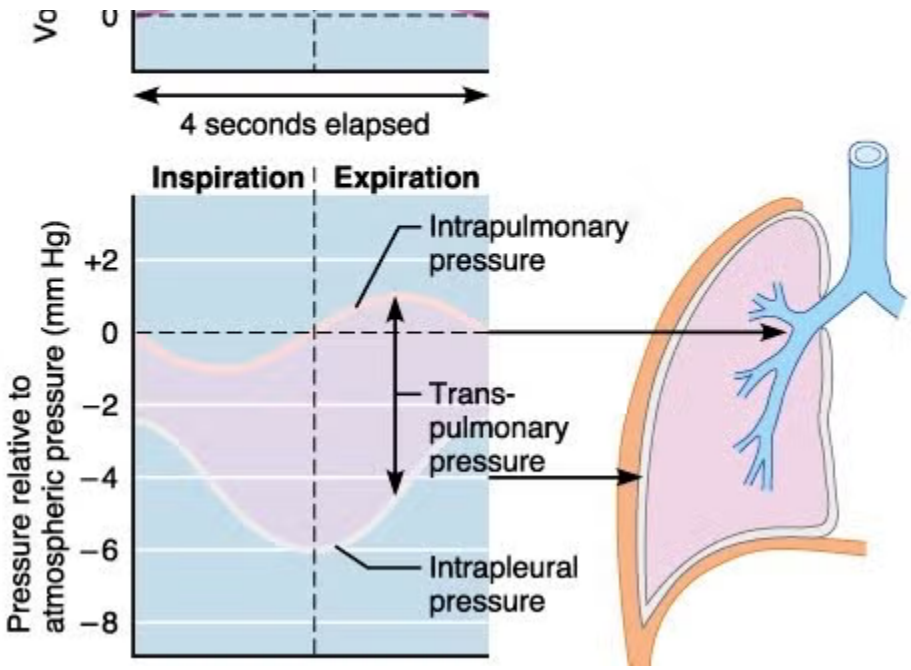
What is lung compliance?
[Photo by Robina Weermeijer on Unsplash]

The Human Lungs

The flow of air into and out of the lungs occurs by bulk flow along pressure gradients created in between the external environment and the alveoli. During quiet breathing, these pressure gradients are created by the contraction of the diaphragm and the external intercostal muscles during inspiration and the elastic recoil of the lungs during expiration.

The alterations in pressure in the pleural space—intra-pleural pressure (P_{pl}) and the alveoli—intra-alveolar pressure (P_{alv}) can be studied separately and become important in studying the volume changes with the changes in pressure.



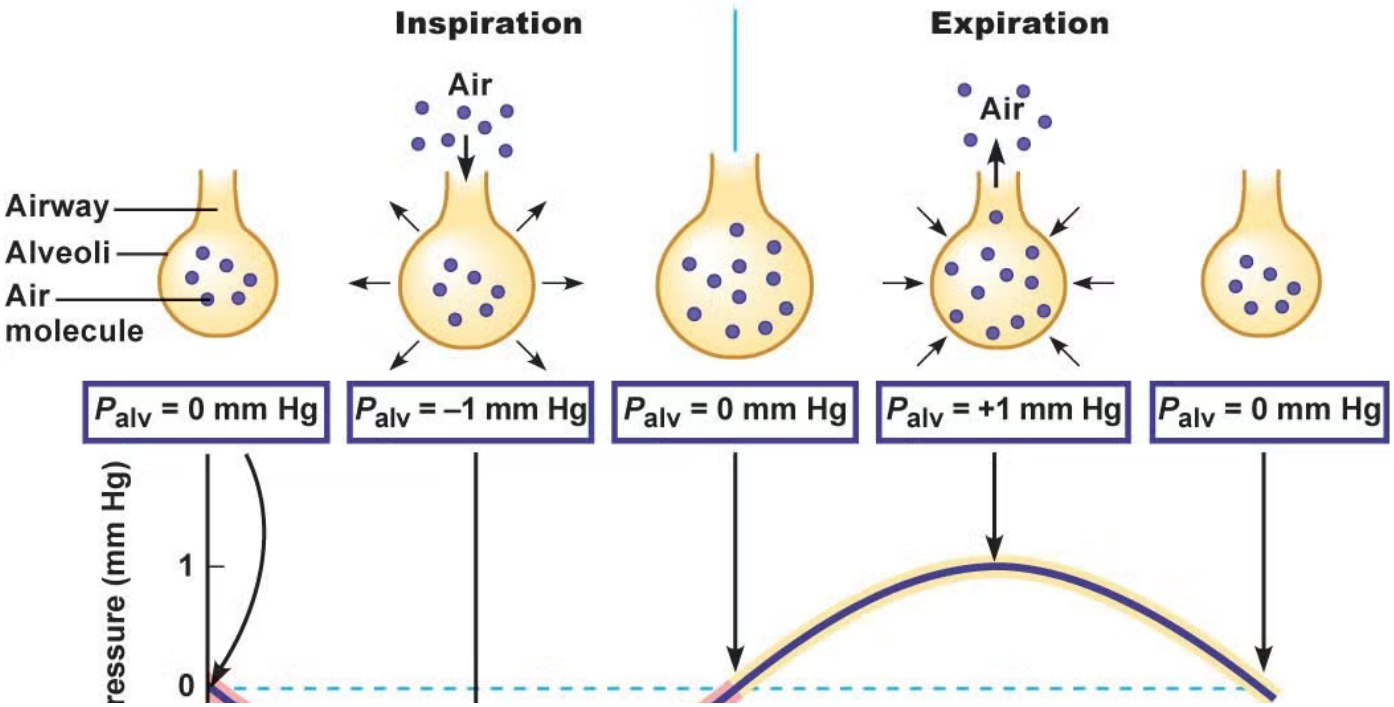


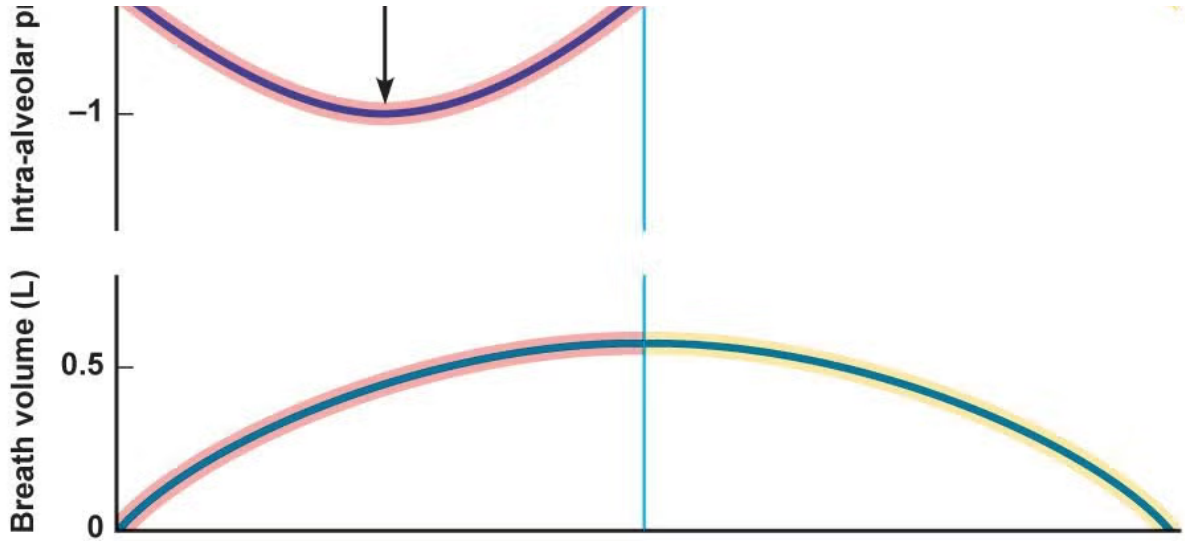
Pressure and volume

1. Changes in Intra-Pleural Pressure During Inspiration

The intra-pleural pressure at the commencement of inspiration is approximately -2.5 cmH_2O (in relation to the atmospheric pressure) at the base of a lung. This is achieved by the elastic recoil forces of the lungs acting inwards and the recoil forces of the chest wall acting outwards.

With the onset of inspiration, the diaphragm contracts and pulls the attached parietal pleura downwards while contraction of the external intercostal muscles pulls the ribcage and the attached parietal pleura outwards. This causes the negativity of the intra-pleural pressure to increase.



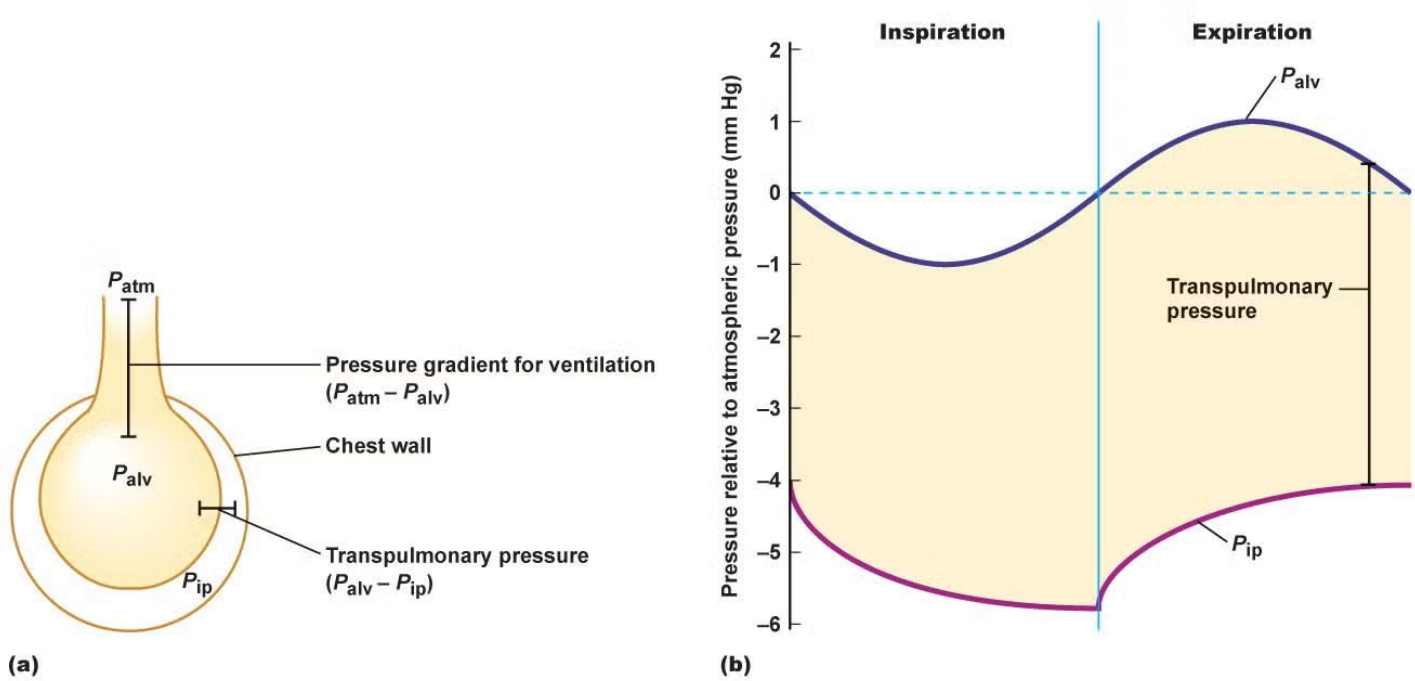


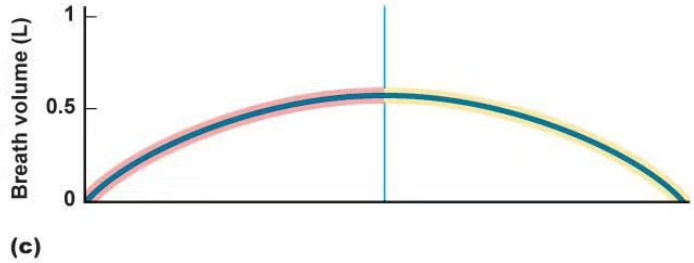
Changes in intra-alveolar pressure

2. Changes in Intra-Alveolar Pressure During Inspiration

When there is no airflow in between the environment and the alveoli, the intra-alveolar pressure = atmospheric pressure. Therefore, the pressure inside the alveoli relative to the atmospheric pressure is 0 cmH_2O. The increased negativity of intra-pleural pressure during inspiration pulls the visceral pleura and the attached lungs outwards (counteracting the elastic recoil forces of the lungs), creating a negative pressure within the alveoli and thereby creating a pressure gradient between the environment (which is at the atmospheric pressure) and the lungs.

Airflows through this pressure gradient, and as the air enters the alveoli, the negativity in pressure decreases. With the cessation of the inspiratory muscle contraction, the intra-alveolar pressure returns to the atmospheric pressure.





3. Changes in Intra-Pleural Pressure During Expiration

During expiration, the elastic recoil of the lungs exerts a force acting inwards. The chest wall also recoils in response, and the negativity of the intra-pleural pressure decreases and returns to the -2.5 cmH_2O towards the end of expiration. The pressure does not rise further as the chest wall exerts a force acting outwards at total lung volumes of less than 4 L.

4. Changes in Intra-Alveolar Pressure During Expiration

With the cessation of inspiratory muscle activity, the outward force exerted by the negative intra-pleural pressure is overridden by the elastic recoil forces of the lungs acting inwards. This causes a positive pressure inside the alveoli in relation to the atmospheric pressure. The air filling the alveoli flows out along the so-formed pressure gradient. This flow of air decreases the positive pressure inside the alveoli, and at a point, the intra-alveolar pressure equalizes with the atmospheric pressure, ceasing the flow of air.

At this point, the sum of forces acting outwards due to the negative intra-pleural pressure and the pressure exerted by the remaining air within the alveoli (=atmospheric pressure) becomes equal to the forces acting inwards due to the elastic recoil of the lungs.

The Transmural Pressures....

In addition to studying the pressure and volume changes that occur within the alveoli, the pressure across the lung, across the chest wall and across the whole respiratory system can be studied against volume changes of the lungs. Thus, three transmural pressures (Pin — Pout) can be defined:

trans-lung or transpulmonary pressure (P_l) between alveoli and the pleural space, i.e., $P_{alv} — P_{pl}$

trans-chest wall pressure (P_w) between the pleural space and body surface, i.e., $P_{pl}, — P_{bs}$

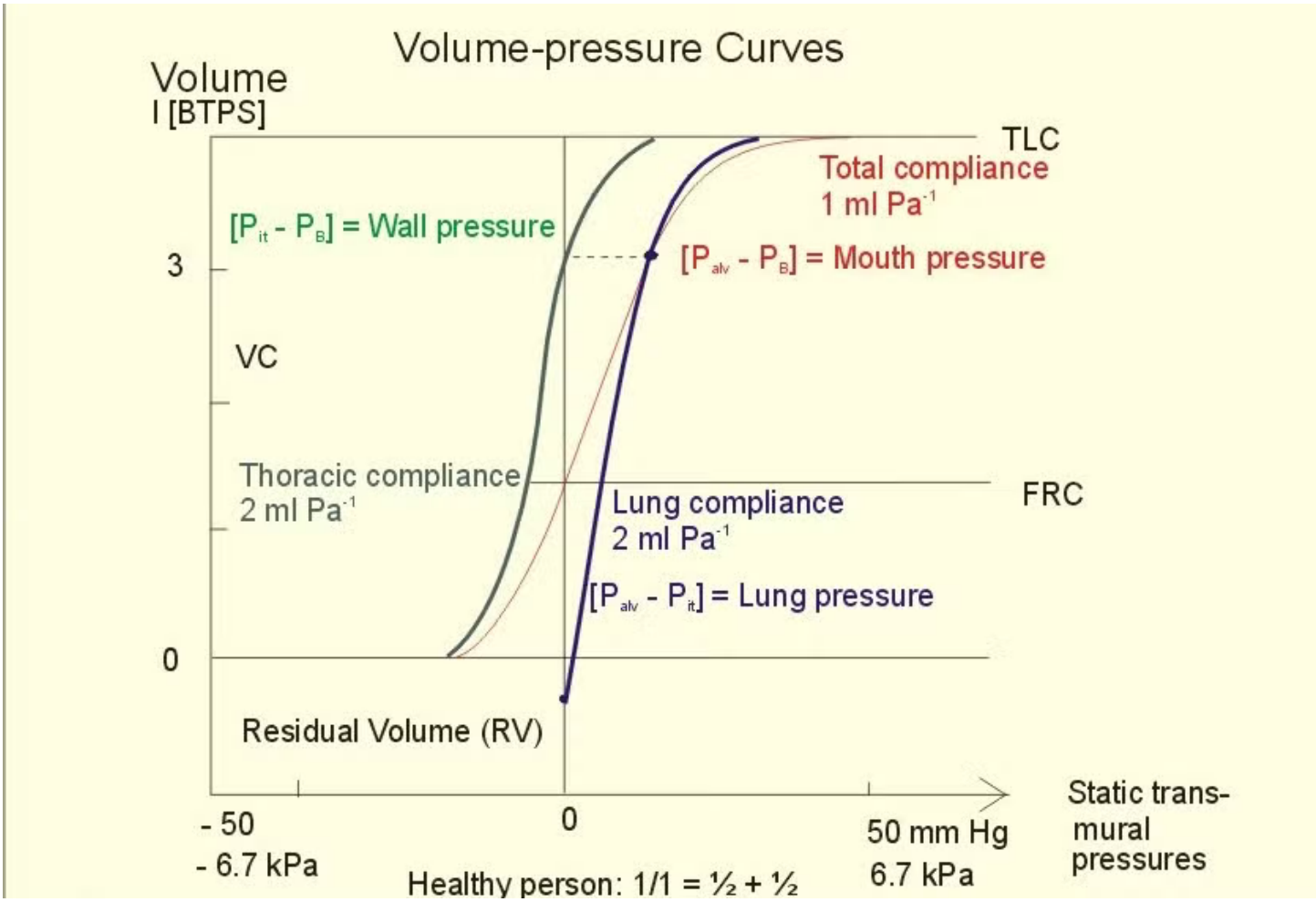
trans-respiratory system pressure (P_{rs}) between the body surface and the alveoli, i.e., $P_{bs} – P_{alv}$

The volume change that occurs in a system per unit pressure change is defined as the compliance of the system. This is the ease at which a structure can be stretched. The compliance of the lungs, chest

wall, and respiratory system can be studied separately by studying the volume changes in the respiratory system against the pressure changes across the respective structure. The pressure-volume curves of the lungs, chest wall, and respiratory system show that the steepest relationship between the volume and the pressure exists in volumes closer to FRC.

This means the compliance becomes highest closer to FRC. The curves tend to flatten as the volume reaches the TLC, i.e., the compliance tends to become less when the lungs and the respiratory system are maximally inflated. The chest wall and the lungs lie in series, forming the respiratory system. Therefore, the compliance of the respiratory system (C_{rs}) has the following relationship to the compliance of the chest wall (C_w) and that of the lungs (C_l):

$1/Crs = 1/Cw + 1/Cl$



Compliance of the Respiratory System

The compliance of healthy lungs is approximately 0.2L per cmH_2O. The compliance of the chest wall is also closer to 0.2 L per cmH_2O. Thus, the compliance of the respiratory system becomes less (0.1L per cmH_2O). Therefore, it is evident that the respiratory system as a whole is less stretchable

compared to the lungs or the chest wall when considered alone.

Compliance Depends on the Size

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Learn More About Volume Changes in Lungs

Lung Volumes and Capacities
Breathing (inspiration and expiration) occurs in a cyclical manner due to the movements of the chest wall and the lungs. The resulting changes in pressure, causes changes in lung volumes.

Learn More About Respiratory Physiology

Respiratory Physiology – Introduction
The respiratory physiology is on the process of incorporation of oxygen in the environment for the utilization of energy from the organic compounds and for the elimination of carbon dioxide

Kasigalire Ronald from muni university ug on March 03, 2019:

this site has helped to understand physiology

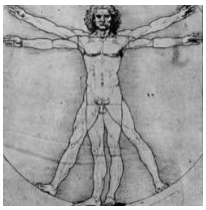
Vijay Kolli on July 05, 2016:

It's very much helpfull

humphrey on September 05, 2014:

i need reference on this publication

tharaka on April 15, 2014:

this site helped me to learn a lot. thanks

About the author